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B8H HAA, G2J JRA JRB1
INT CL[5] A01G, B66C, F16F

(54) **Counter balance**

(57) The invention relates to a mechanism for balancing the weight of an object to be swivelled about a pitch axis, especially for balancing the weight of a film or television camera mounted on a tripod head. The pitching torque produced during swivelling of the object (2) is compensated by a restoring torque, which acts with the aid of a spring arrangement (12) on the pitch axis (A) via a lever arm (11). In order to increase the pitching range and to achieve an ideal compensation of torque for all pitch angles, it is proposed according to the invention that the balancing mechanism (1) has a reduction gear (5) with a reduction ratio of 1:2 between an input shaft and an output shaft (4 and 8, respectively), the axis of the input shaft (4) being the pitch axis (A), and the spring arrangement (12) acting on the output shaft (8) via a lever arm.

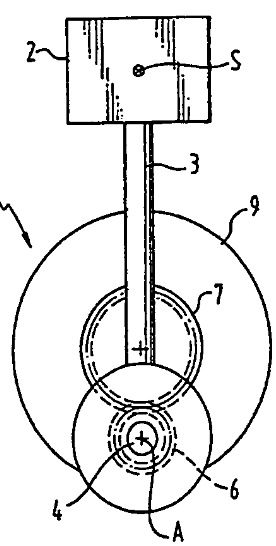

Fig. 1

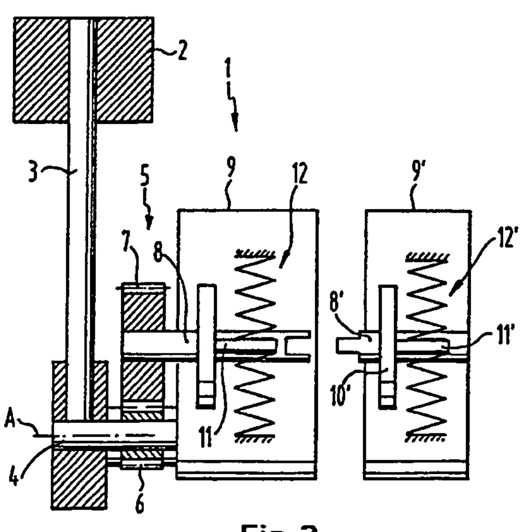

Fig. 2

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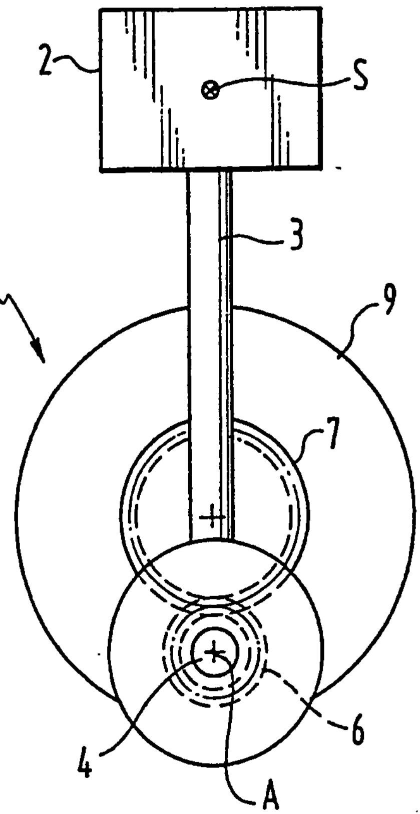

Fig. 1

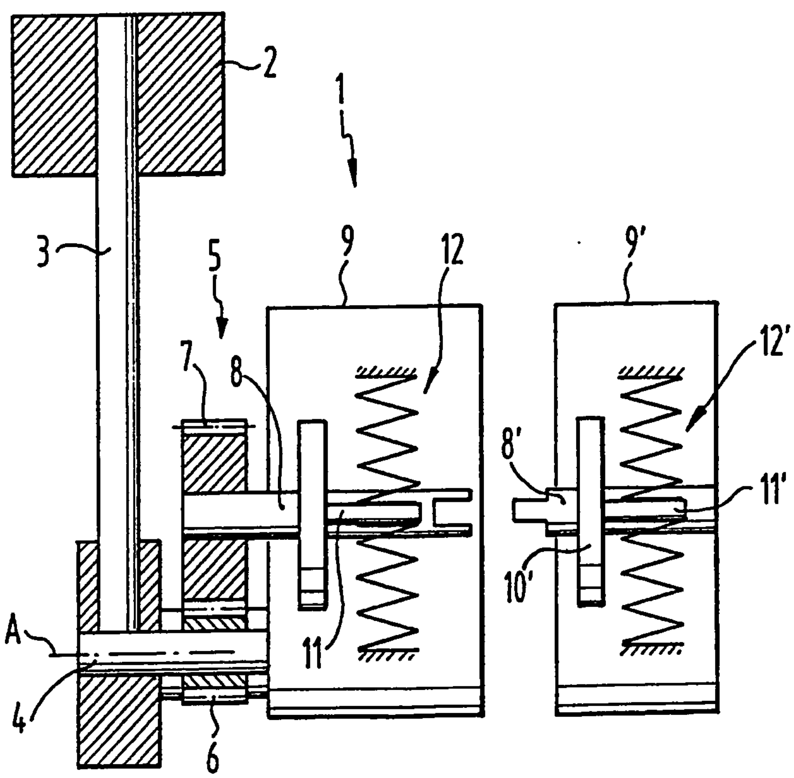

Fig. 2

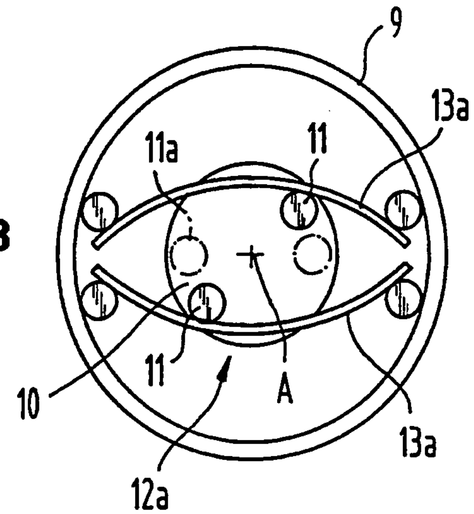

Fig. 3

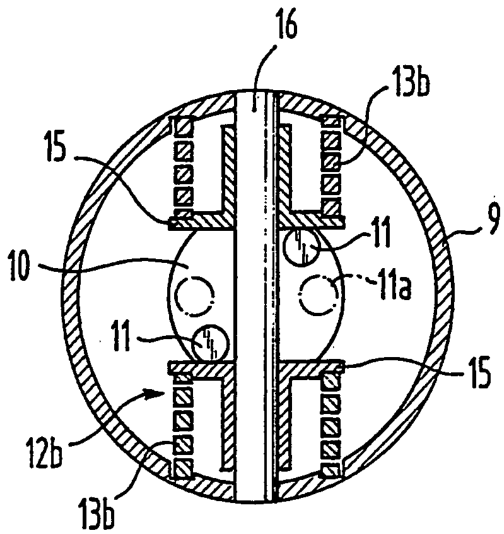

Fig. 4

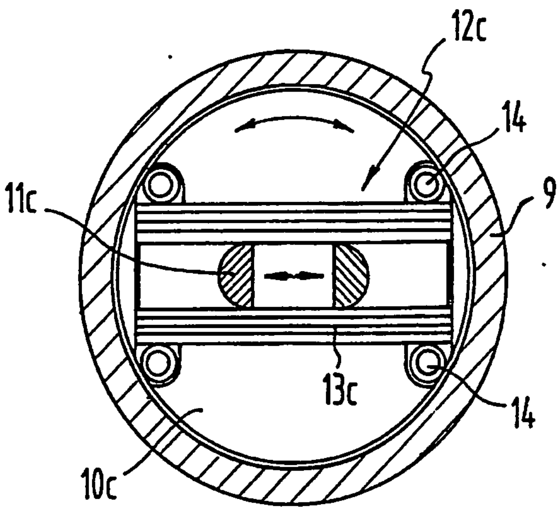

Fig. 5

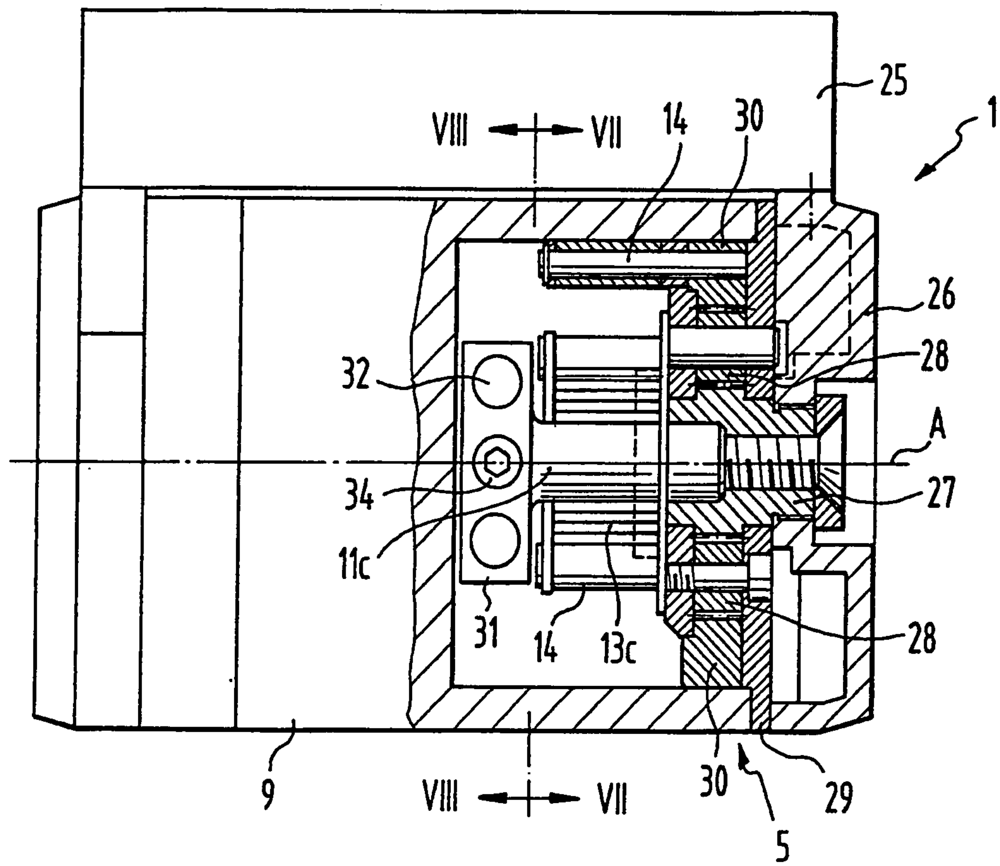
25
1
VIII
VII
14
30
26
28
32
A
34
27
11c
28
31
14
13c
9
VIII
VII
30
29
5

Fig. 6

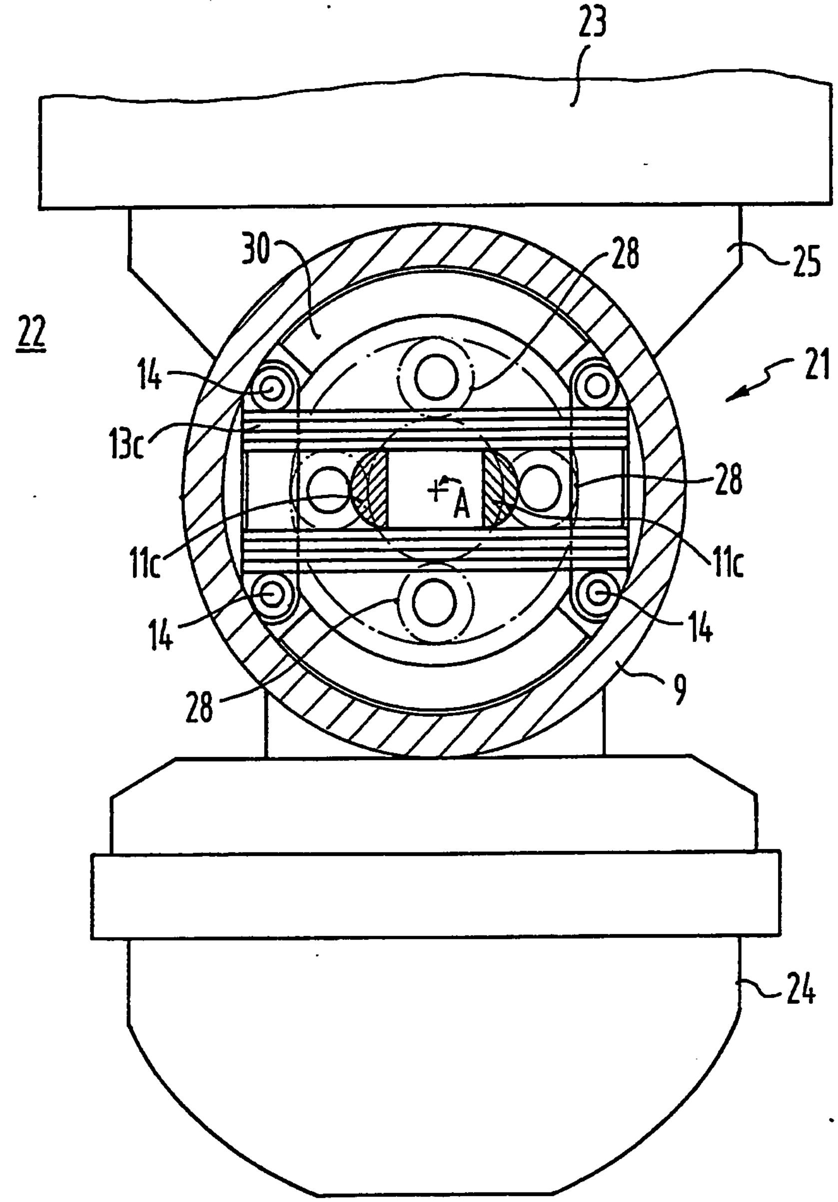

Fig. 7

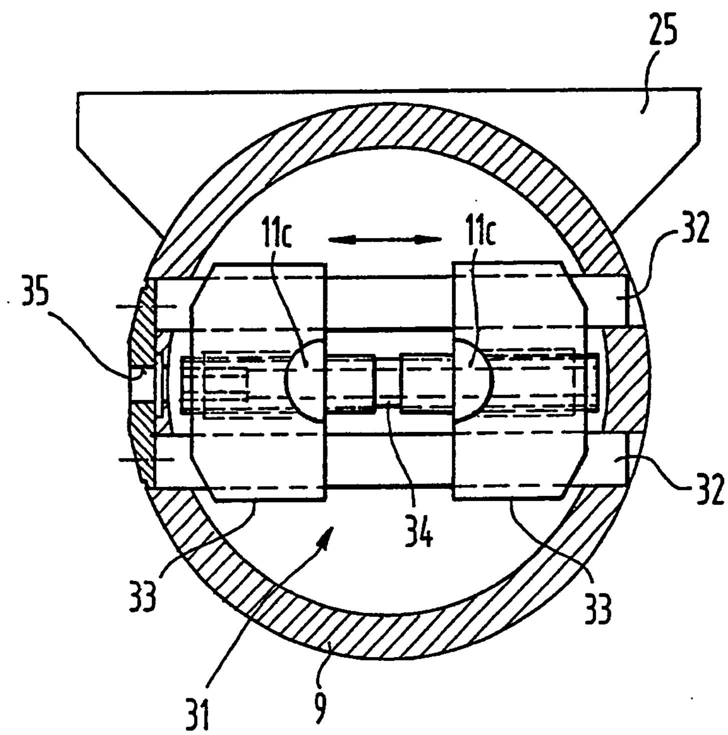

Fig. 8

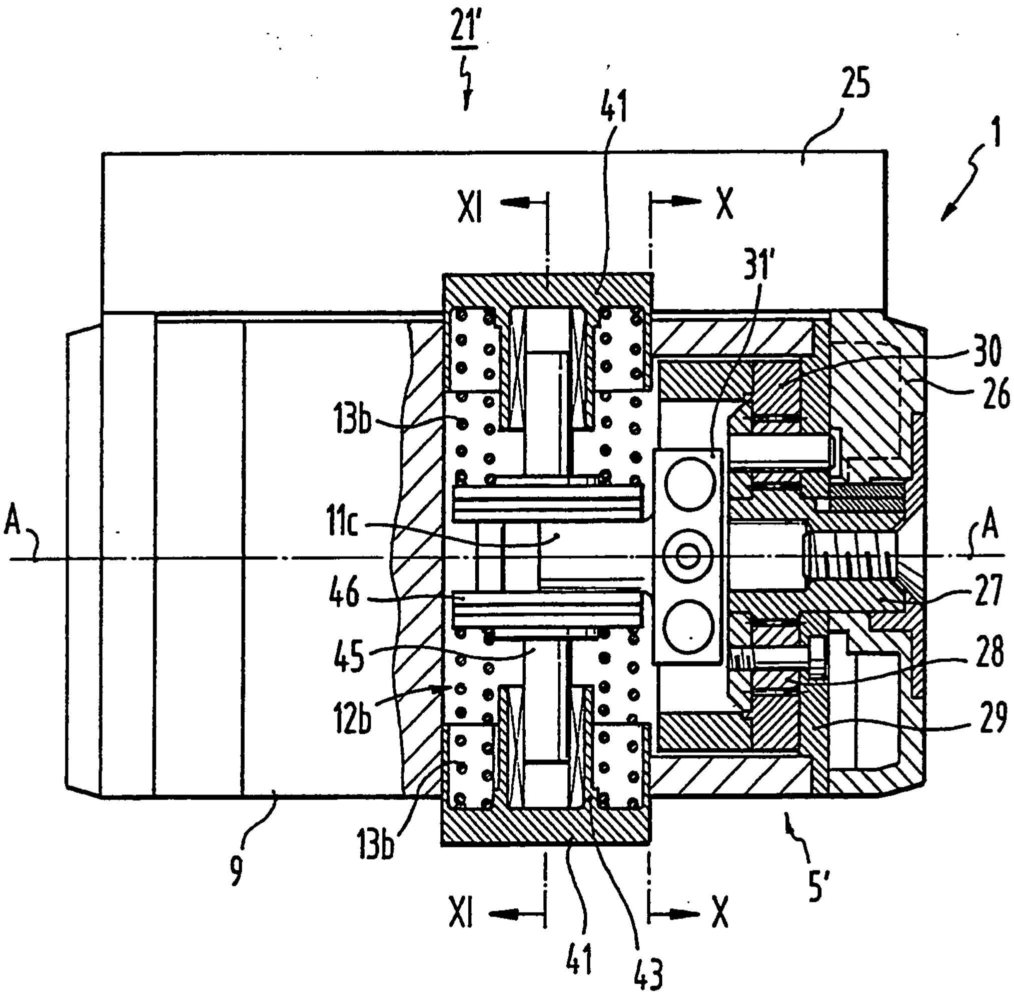

Fig. 9

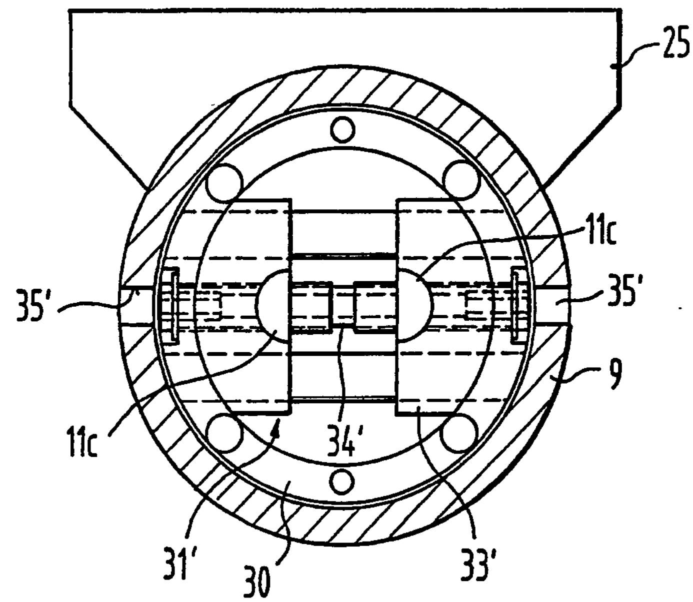
25
11c
35'
35'
9
11c
34'
31'
30
33'

Fig. 10

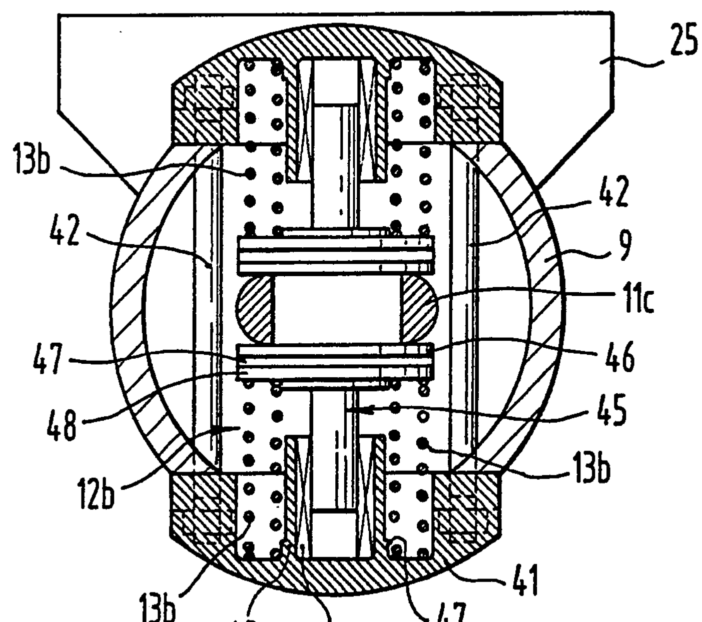
25
13b
42
42
9
11c
47
46
48
45
12b
13b
13b
41
43
44
47

Fig. 11

MECHANISM FOR BALANCING THE WEIGHT OF AN OBJECT

The invention relates to a mechanism for balancing the weight of an object to be swivelled about a pitch axis, especially a film or television camera mounted on a tripod head, in accordance with the preamble of Patent Claim 1.

Only weight balancing for a film or television camera will be considered below as an example, but this does not exclude application to the weight balancing of other appliances, such as, e.g., telescopes, medical apparatuses or the like.

The torque or pitching torque produced by the camera in a pitching position obeys a sine law, and is the product of the weight of the camera, the distance of the centre of gravity of the camera from the pitch axis, and the sine of the pitch angle, the latter being set equal to zero when the centre of gravity of the camera is located vertically above the pitch axis.

Thus, the balancing mechanism should produce a restoring torque which corresponds to the pitching torque of the camera in the corresponding pitching position. The camera consequently remains in the particular pitching position without it being necessary for retaining forces to be applied.

German Patent Specification 3,026,379 discloses a balancing mechanism which is installed in a tripod head for a camera and has a plurality of sets of springs of spiral springs or flat rubber springs with different spring forces, which can be locked individually or in combination with the housing of the tripod head and the pitch axis. With such a design it is possible to balance pitching torques of cameras of different weight.

Since spiral springs deliver a restoring force which is proportional to the angle of deflection, i.e. here the pitch angle, while the pitching torque of the camera obeys a sine law, a weight balancing can take place only over a limited angular range in which the sine can be approximated by a straight line. The spring characteristic can be better fitted to the sine law by appropriate configuration of the flat rubber springs.

With this mechanism, a weight balancing which is adequate in practice can take place up to pitch angles of at most 60°.

German Offenlegungsschrift 2,952,660 likewise discloses a balancing mechanism in conjunction with cameras on tripod heads, in which mechanism the rotor connected to the pitch axis acts via a bolt with the corresponding receiving device for the camera on a compression spring arrangement, the bolt being slidable in the rotor, so that the effective lever arm via which the restoring torque is produced can be continuously varied. With this balancing mechanism, as well, the restoring torque is approximately equal to the pitching torque only in a limited pitching range, this range being even smaller than in the case of the abovementioned balancing mechanism. A further disadvantage is that in the event of a pitching movement the bolts each act only unilaterally on a compression spring. Relatively large play is present, especially in the case of load reversals and in the zero position, so that this balancing mechanism is scarcely of use in practice.

A system used in practice is disclosed in British Patent Application 2,189,042. A spring of adjustable spring force is employed for the weight balancing. Although this balancing mechanism can thereby be adjusted to different camera weights, the same disadvantages in relation to the limited pitching range in which a compensation of the pitching torque is achieved apply to this mechanism, as well.

All the known balancing mechanisms thus deliver only an approximate balancing of torque, and this, moreover, only over a limited pitch angle. In addition, the spring excursions are considerable, so that high demands are to be placed on spring quality.

It is the object of the invention to specify a mechanism of the type under discussion with which the pitching torque is compensated by the restoring torque over a wide pitch angle range, the aim being for this to be achieved with a simple design and short spring

excursions and, moreover, the possibility existing of extending the mechanism so that the restoring torque can be adjusted to different pitching torques.

In accordance with the invention, this object is achieved with the features specified in the characterizing part of Patent Claim 1.

Accordingly, the idea is to connect the pitch axis to a reduction gear, the output shaft of this gear, which rotates more slowly in conformity with the reduction ratio, then being connected to the spring arrangement via a lever arm. If the reduction ratio is 1:2 and if the spring force acts in a direction which is perpendicular to the direction which corresponds to the rest position of the lever arm, the effective lever arm is proportional to the cosine of half the pitch angle alpha, and the spring force in the case of a compression spring is proportional to its deflection, i.e. proportional to the sine of half the pitch angle. The restoring torque is therefore proportional to the product sin $\alpha/2$ x cos $\alpha/2$. Since this product corresponds to half the sine of the pitch angle α, the restoring torque can be rendered exactly oppositely equal to the pitching torque by choice of the spring strength and adjustment of the lever arm.

Even if a departure is made from the ideal values given above, better results are acheived than is the case in the prior art. If, e.g., a reduction gear with a reduction ratio of 1:1.5 is chosen, the restoring torques deviate in a swivelling range of +/- 80° by only +/- 15 % from a mean value, while for a gear with a reduction ratio of 1:2.5 the deviation is even only +/- 6 %. With a conventional weight balancing, in which the lever arm sweeps out the pitch angle range, the error in relation to a mean value already amounts to +/- 20 % for a swivelling range of only 50°. However, in practice, reduction ratios which are too high, for example up to a value of 1:5, are probably not so suitable, since the output shaft of the reduction gear then also rotates by only a small angle in the case of large pitch angles, and considerable spring forces are necessary, in part.

Similar considerations also apply to the direction of action of the spring force. If this direction of action is constant over the entire pitching range or angular range of the lever arm, the component which is perpendicular to the direction and corresponds to the rest position of the lever arm is also constant. Since the cosine changes only slightly at the small angle of rotation of the output shaft of the gear, it is also possible to accept a direction of the spring force which changes during the swivelling movement and which can be larger the larger, the reduction ratio. In the case of the reduction ratio of 1:5 mentioned above, between 0 and 80° the cosine changes only between the value 1 and the value 0.96, i.e. only by approximately 4 %. In a few instances, it is possible to accept a variation in the direction of application of the spring force by an angle of up to +/- 45° to the abovementioned ideal direction.

It is preferable to provide two spring arrangements, e.g. leaf springs or compression springs, which are arranged on opposite sides of the output shaft of the gear and cooperate in each case with a lever arm so that both springs are pressurized in all pitching positions. Each spring therefore need compensate only half the pitching torque; in addition, it is guaranteed that the mechanism will function without play even in the case of load reversals.

For the purpose of the transmission of force between spring arrangement and lever, either the lever is connected in a rotationally firm fashion to the output shaft of the gear and the spring arrangement is stationary, or the spring arrangement is connected in a rotationally firm fashion to the output shaft and the lever is stationary. Kinematically and in terms of function, the two designs are equivalent.

It is evident that the restoring torque produced with the mechanism at a predetermined spring strength can be varied by changing the length of the lever arm between the axis of the output shaft of the gear and the direction of application at the spring arrangement. For

this purpose, it is preferable to apply a slide arrangement of two slides which are coupled by a spindle and each carry a bolt bearing against the spring arrangement.

In principle, any gear can be used as reduction gear. An elegant possibility is provided by a sun-and-planet gearing, since the input and output shaft are hereby coaxial. For a reduction ratio of 1:2, the pitch shaft is the shaft of the sun wheel, the planet wheels being held in their place, and the hollow shaft of the internal geared wheel is the output shaft of the gear. Since the input and output shaft are coaxial, a compact design is possible for the balancing mechanism, which is to be easily installed, e.g., in a tripod head housing for a film or television camera.

Further embodiments of the invention follow from the subclaims.

The invention is explained in more detail in illustrative embodiments with reference to the drawing, wherein:

Figs. 1 and 2 represent a diagrammatic view or a partially cut away diagrammatic side elevation of a balancing mechanism in accordance with the invention, in order to explain it;

Figs. 3 to 5 represent diagrammatic partially cut away views of spring arrangements which can be employed in conjunction with the balancing mechanism;

Fig. 6 represents a partially cut away view of a balancing mechanism in accordance with the invention with a sun-and-planet gearing, which is installed in the pitching part of a tripod head for a film or television camera;

Fig. 7 represents a section along VII-VII in Fig. 6;

Fig. 8 represents a section along VIII-VIII in Fig. 6; and

Figs. 9 to 11 represent a second illustrative embodiment of a balancing mechanism in accordance with the invention in views or sections in accordance with Figs. 6 to 8.

Represented diagrammatically in Figs. 1 and 2 is a balancing mechanism 1 with which the weight of an object 2, having the centre of gravity S, is to be balanced by swivelling about a pitch axis A. The object 2 is connected via a rod 3 to a horizontal shaft 4 whose axis is the pitch axis A. The pitch axis A and the rod 3 are perpendicular to one another. The shaft 4 is the input shaft of a gear with the reduction ration 1:2, and carries a toothed wheel 6, which meshes with a further toothed wheel 7 having double the number of teeth. The shaft of this toothed wheel 7 is the output shaft 8 of the gear 5. If the object 2 is swivelled about the pitch axis A by a specific angle, the output shaft 8 rotates by half the angle.

The output shaft 8 is connected in a housing 9 of the balancing mechanism 1 to a carrier 10, e.g. a wheel, which, for its part, carries on both sides of the shaft axis one bolt 11 each, which are aligned parallel to said axis and interact in each case with a spring arrangement 12 (indicated only diagrammatically).

As an example of such spring arrangements, Figs. 3 and 5 each show a leaf spring arrangement 12a or 12c, and Fig. 4 shows a compression spring arrangement 12b.

The leaf spring arrangement 12a in accordance with Fig. 3 has two leaf springs or sets of leaf springs 13a, which in each case bear with the ends against support bolts 14 which are stationary in the housing 9. The support bolts are arranged in this case so that in the rest position of the bolts 11 indicated by 11a the leaf springs 13a are extended and bear against both sides of the bolts 11. If the object S is then swivelled about the pitch axis A, the wheel 10 rotates and the bolts 11 correspondingly expand the springs 13a, so that a restoring torque is produced which is directed opposite to the pitching torque of the object 2.

When the leaf springs 13a are expanded, their ends slide on the support bolts 14. The sliding resistance can be reduced by appropriate choice of material or by constructing the support bolts as rollers on which the

spring ends slide.

The spring arrangement 12b in accordance with Fig. 4 has two compression springs 13b, which are supported with one end in each case in the wall of the housing 9, and act at their other end in each case on a pressure plate 15, the two pressure plates sliding on a fixed shaft 16 running radially through the housing 9. If the bolts 11 are located in the rest position marked by 11a, the pressure plates 15 bear against the bolts on both sides thereof. If the object 2 is swivelled, the two compression springs 13b produce a restoring torque which, given appropriate rating of the spring constant, corresponds exactly to the pitching torque of the object 2.

In the case of the designs in accordance with Figs. 3 and 4, it is the bolts 11 which are rotated in each case, while the springs are supported fixed with respect to the housing. Of course, a kinematic reversal such as is shown in Fig. 5 is possible. The spring arrangement 12c comprises two sets of leaf springs 13c, which bear, as in Fig. 3, with their ends against a corresponding support bolt 14. These support bolts are arranged on a carrier, e.g. a large wheel 10c, which is connected in a rotationally firm fashion to the output shaft 8 of the reduction gear. Here, the bolts interacting with the springs 13c are bolts 11c of semicircular cross-section which, for their part, are attached to the housing 9. If the weight 2 is swivelled, the wheel 10c rotates with the spring arrangement 12c arranged thereon, while the bolts 11c remain fixed with respect to the housing, so that the springs 13c are expanded and, given appropriate choice of the spring constant, produce a restoring torque which is oppositely equal to the pitching moment of the object 2.

In all instances, this restoring torque depends, on the one hand, upon the abovementioned spring constant and, on the other hand, upon the spacing of the bolts from one another or upon the spacing of the bearing point of the bolts against the springs and the axis of rotation of the shaft 8 or of the wheel 10c. In order to be able

to adjust the restoring torque over a specific range, so that the balancing mechanism is effective for objects of different weight, in the case of all the embodiments the bolts can be slid symmetrically to the axis of the shaft 8, as is indicated in the figures by the arrows.

The minimum adjustable restoring torque then occurs when the bolts bear directly against one another. In the design in accordance with Fig. 5 with the two bolts 11c of semicircular cross-section, the minimum restoring torque is zero. It is true that in the case of the other two designs with bolts of circular cross-section, said bolts can also be brought directly into contact, but then a slight restoring torque is still applied upon pitching of the object and amounts to approximately 10 % to 25 % of the pitching torque, depending upon the diameter of the bolts.

Adjusting the restoring torque to the particular pitching torque which depends upon the weight of the object can also be done in another way, as indicated in Fig. 2. In addition to the housing 9 already described, the balancing mechanism 1 can also have a further one or plurality of housings 9′, each of the same design, with a shaft 8′, a carrier 10′ and with bolts 11′, and a spring arrangement 12′. The shaft 8 of the spring housing 9 and the shaft 8′ of the additional spring housing 9′ can be coupled to one another, so that overall the restoring torque is thereby increased. The individual spring arrangements 12, 12′ etc., preferably have different spring strengths. The pitching torque exerted by the object can be balanced by the series connection of suitable spring housings, which overall deliver the restoring torque corresponding to the pitching torque. A second possibility consists in using one of the two spring housings to produce a basic restoring torque, while the second spring housing is equipped with adjustable bolts for the fine adjustment of the restoring torque.

Represented in Figs. 6 to 8 is a pitching part 21 of a tripod head 22, shown diagrammatically in Fig. 7,

for a film or television camera 23 (only indicated). This pitching part 21 is mounted in accordance with Fig. 7 on a swivelling part 24 with which the camera can be swivelled about the vertical axis. The reference symbols of Figs. 1 to 5 are employed for the following description.

The camera 23 is mounted on a receiving device 25, which is connected to the housing 9 of the pitching part 21. Arranged in one half of the housing 9 is a balancing mechanism 1 whose operating principle resembles the balancing mechanism in accordance with Fig. 5. Arranged in the other half of the housing 9 is a damping device (not shown here) with which pitching movements are damped and moderated.

In this design, the reduction gear is a sun-and-planet gearing 5' which is arranged inside the housing 9. The receiving device 25 is connected to a sealing cover 26 which is connected in a rotationally firm fashion to a sun wheel 27 of the sun-and-planet gearing 5'. The horizontal axis of rotation of the sun wheel 27 is the pitch axis A. The sun wheel 27 meshes with four planet wheels 28, which are arranged on a planet carrier 29 which, for its part, is firmly connected to the housing 9. The planet wheels 28 are surrounded by an internal geared wheel 30, from which four support bolts project, parallel to the pitch axis A, into the interior of the housing 9. In a manner similar to the illustrative embodiment in accordance with Fig. 5, on both sides of the pitch axis two sets of leaf springs 13c are supported on these support bolts. Two bolts 11c of semicircular cross-section, which, in accordance with Fig. 8, are supported in a longitudinally slidable fashion on a carrier 31 fixed with respect to the housing, engage between the sets of leaf springs (cf. Fig. 7). On both sides of the pitch axis, this carrier 31 has two slide rods 32 on which two slides 33 are supported, which carry the bolts 11c on their facing edges. The two slides 33 are connected to one another by a spindle 34, which is accessible from outside via a bore 35 in the outer wall

of the housing 9, and is to be twisted, whereby the two slides are adjusted and the spacing between the two bolts can be varied, as is indicated by the double arrow in Fig. 8.

If the camera 23 is swivelled by a specific angle about the pitch axis A, the internal geared wheel 30 of the sun-and-planet gearing 5′ rotates by half the angle because of the planet carrier 29, which is held in place, and thereby carries the sets of springs 13c along with it. These sets of springs 13c are extended by the bolts 11c, so that a restoring torque acts on the receiving device 25 and thus on the camera 23. By appropriate choice of the spring strengths, and by adjustment of the spacing between the bolts 11c, the restoring torque is adjusted to the pitching torque of the camera 23. Since the carrier 31 for the slides 33 of the bolts 11c is fixed with respect to the housing, this adjustment can take place especially simply and, in principle, for any pitching position of the camera.

A further illustrative embodiment is given in Figs. 9 to 11 for a pitching part 21′ of a tripod head. The principle of design and operation of the balancing mechanism 1 employed here corresponds to that of the balancing mechanism in accordance with Fig. 4. The balancing mechanism 1 is integrated in the housing 9 of the pitching part 21′, and has a sun-and-planet gearing 5′. The arrangement of the sun-and-planet gearing with the sun wheel 27, the planet wheels 28, the planet carrier 29 and the internal geared wheel 30, as well as the connection of the sun-and-planet gearing 5′ to the receiving device 25 via a sealing cover 26 corresponds to the preceding illustrative embodiment, and will therefore not be described in more detail. A carrier 31′ for the bolts 11c arranged on slides 33′ is connected to the internal geared wheel 30 (cf. Fig. 10). This carrier 31′ is constructed like the carrier 31 in Fig. 8, so that the slides 33′ slide on slide rods 32′, and the spacing of the bolts 11c from one another can be adjusted with the aid of a spindle 34′. Two bores 35′ are provided in the

outer wall of the housing 9, their axes being flush with the spindle axis when the camera is located in the rest position, i.e. when its centre of gravity is located vertically above the pitch axis A. In this position, the spacing between the bolts 11c can be varied by twisting the spindle from outside.

The two bolts 11c each act on a compression spring 13b of a spring arrangement 12b. The spring arrangement 12b is arranged between two caps 41, which are situated on opposite sides of the housing 9 and are connected to one another with the aid of staybolts 42 running through the housing. Provided in the middle of each cap 41 is a sleeve 43 whose central axis runs in the direction of a diameter of the housing 9 and in whose interior a linear bearing 44, e.g. a ball bearing, is arranged. The axis of a pressure piston 45 is supported in the sleeve with the bearing. This pressure piston 45 has a hardened and ground thrust plate 46, which bears against the two bolts 11c in the rest position of the camera. The thrust plate covers a thrust bearing 47, e.g. a roller bearing or a needle bearing, which is arranged between the thrust plate 46 and a force plate 48. Bearing against the side of the force plate 48 averted from the bolts 11c is one end of a compression spring 13b, of which the other end is situated in a groove 49 running around the sleeve 43 in the particular cap 41.

When the camera is swivelled, the compression springs 13b are compressed, purely the forces acting in the longitudinal direction of the piston being passed on by the needle bearing 47. The forces arising upon compression of the springs 13b are absorbed by the caps 41 and by the staybolts 42, so that, overall, the housing 9 is only moderately stressed.

Instead of the abovementioned leaf springs and compression springs, it is also possible to use other springs, e.g. rubber springs approximately in the form of rubber blocks, or even disc springs, the latter especially when the aim is to balance the weight of heavy cameras.

CLAIMS

1. Mechanism for balancing the weight of an object to be swivelled about a pitch axis in different pitching positions (balancing mechanism), the centre of gravity of the object falling outside the pitch axis, having a spring arrangement which acts on the pitch axis via a lever arm and generates about said pitch axis a restoring torque, which is defined by the spring constant of the spring arrangement and by the lever arm, and is opposed, and essentially equal, to the pitching torque of the object, especially a mechanism for balancing the weight of a film or television camera which can be swivelled on a tripod head about a pitch axis, characterized in that the balancing mechanism (1) has a reduction gear (5, 5') with an input shaft and an output shaft (4 or 8), in that the axis of the input shaft (4) is the pitch axis (A), and in that the spring arrangement (12, 12a, 12b, 12c) acts on the output shaft (8) via at least one lever arm (11, 11c).

2. Mechanism according to Claim 1, characterized in that the reduction ratio of the reduction gear (5, 5') falls between 1:1.5 and 1:3.

3. Mechanism according to Claim 1, characterized in that the reduction ratio of the reduction gear (5, 5') falls between 1:2.

4. Mechanism according to one of the preceding claims, characterized in that the spring force acts on the lever arm (11) in the rest position thereof, i.e. when the object (2,23) is not swivelled, in a range from +/- 45° about the vertical.

5. Mechanism according to Claim 4, characterized in that the spring force acts in a direction which is perpendicular to the direction which corresponds to the rest position of the lever arm (11).

6. Mechanism according to one of the preceding claims, characterized in that the reduction gear (5) is a toothed-wheel gear.

7. Mechanism according to one of the preceding claims, characterized in that the reduction gear is a sun-and-planet gearing (5') with sun wheel (27), planet wheels (28) and planet carrier (29), as well as internal geared wheel (30), the input shaft with the pitch axis (A) being the shaft of the sun wheel (27), the output shaft being the shaft of the internal geared wheel (30), and the planet carrier (29) being held in place.

8. Mechanism according to one of the preceding claims, characterized in that at least one bolt (11, 11c), which bears against the spring arrangement (12, 12a, 12b, 12c) connected to a housing (9) of the balancing mechanism (1), is connected to the output shaft (8) of the reduction gear (5, 5').

9. Mechanism according to one of Claims 1 to 7, characterized in that the spring arrangement (12c) is connected to the output shaft (8) of the gear (5, 5'), and in that the spring arrangement bears against at least one bolt (11c), which is connected to a housing (9) of the balancing mechanism (1).

10. Mechanism according to Claim 8 or 9, characterized in that two bolts (11) are provided which are situated symmetrically to the axis of the input shaft (8) of the reduction gear (5, 5').

11. Mechanism according to Claim 10, characterized in that each bolt (11) is assigned a spring (13), which bears against the bolt (11) in each pitching position of

the object.

12. Mechanism according to Claim 10 or 11, characterized in that the bolts (11, 11c) are arranged on a carrier (31, 31').

13. Mechanism according to one of Claims 8 to 12, characterized in that the spacing of the bolts (11, 11c) from the axis of the output shaft (8) of the reduction gear (5, 5') is variable.

14. Mechanism according to Claim 13, characterized in that each bolt (11c) is arranged on a slide (33, 33').

15. Mechanism according to Claim 14, characterized in that the bolts (11c) each have a semicircular cross-section and are arranged on the mutually facing edges of the slides (33, 33') in such a way that they bear against one another when the slides have been fully brought together against one another.

16. Mechanism according to Claim 14 or 15, characterized in that the slides (33, 33') are coupled to one another via a common spindle (34, 34').

17. Mechanism according to one of the preceding claims, characterized in that the spring arrangement (12a, 12c) has at least one leaf spring (13a, 13c) whose longitudinal axis is arranged transverse to the output shaft (8) of the gear (5, 5').

18. Mechanism according to one of Claims 1 to 16, characterized in that the spring arrangement (12b) has at least one compression spring (13b) whose spring axis is perpendicular to the axis of the output shaft (8) of the gear (5, 5').

19. Mechanism according to one of the preceding claims, characterized in that the balancing mechanism (1) consists of at least two units (9, 9'), the first unit being connected to the reduction gear (5) and the second unit having only a shaft (8'), a spring arrangement (12') and a lever arm (11'), and in that the shaft (8') of the additional units (9') can be connected in a rotationally firm fashion to the output shaft (8) of the gear (5) of the first unit (9).

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